Clean Mobility Development

Hyundai Fuel Cell Truck

Mark Freymüller, Hyundai Motor Company
Clean Mobility Development

1,000 Fuel Cell Trucks in customer operation in Switzerland until 2023 starting in 2019
In a few minutes
Still charging

Short haul
Light Duty Truck
Pay-load
Low

In a few minutes
Fully charged

Long haul
Heavy Duty Truck
Pay-load
High

EV Truck
less loads

FCEV Truck
more loads
Clean Mobility Development

1,000 fuel cell electric trucks in Switzerland
Clean Mobility Development

The hydrogen cycle
Different roadmaps in Europe to reduce CO$_2$ emissions
Presentation at HFC-Nordic 2018

Introduction of FC-HD-Truck-Fleet in Switzerland
Prerequisites and current status

Thomas Walter, H₂ Energy

Reykjavik  October 10th, 2018
Profile H₂ Energy AG

Value add and activities
- Emission free, grid-friendly, renewable heavy duty transportation system for truck operators
- Components and systems for non-automotive applications
- Hydrogen engineering services

Entrepreneurs/shareholders

Geographics and products
- Switzerland: hydrogen production, commercial vehicles, back-up power, trains, ferries, real estate applications, etc.
- Germany/Austria: hydrogen production
- Norway: high speed ferries, hydrogen production
Profile Coop in Switzerland – activities and key figures

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<th>Retail</th>
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<td>Nutrex</td>
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<td>Pearlwater</td>
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- Leader sustainability and organic food (bio)
- Leading supermarket in Switzerland
- More than 20 specialized formats, 8 producing companies, TransGourmet Group

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Net sales Coop Group, 2017 | 3'240 Bio. ISK (24 Bio. EUR)
Number of stores, 2017     | Retail 2’295
Staff, 2017                 | 86’320
### Key figures Coop Mineraloel AG – Coop Pronto

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues Coop Mineraloel AG, 2017</td>
<td>250 Bio. ISK (1.8 Bio. EUR)</td>
</tr>
<tr>
<td>Number of filling stations, 2017</td>
<td>241</td>
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<tr>
<td>Coop Pronto Shops 2017</td>
<td>296</td>
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<tr>
<td>Sales surface area</td>
<td>35’659 m²</td>
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- No 1 operator in Switzerland
- CMA franchise model
- 51/49 JV with Phillips 66 (Conoco Group)
Coop’s road to Decarbonisation  
(as declared in year 2008)

For Coop, "CO₂-neutral by 2023" means:

by 2023, taking all the technically feasible and financially expedient measures to reduce CO₂ emissions as much as possible in absolute terms

from 2023 onwards, offsetting residual CO₂ emissions by means of suitable projects, i.e. emissions that can only be avoided at excessive cost or that simply cannot be prevented
The Coop Hydrogen Task

Value add in Europe/Switzerland

Closed cycle and minimizing CO₂ emissions

Basic interests Coop Retail:
- Decarbonisation

Coop’s Closed Renewable Hydrogen Cycle

Profitability (long-term)

Basic interests Coop Petrol stations:
- Future business model

Basic interests Coop Group:
- Market potential
- Social activity
Hydrogen is most promising future technology for decarbonisation of on-road transportation

Vehicle fleet of COOP
- HD- and LD-Rigid trucks with/without refrigeration unit
- HD-tractors

Fleet size COOP
- > 200 trucks for distribution

Fleet size contractors
- > 200 trucks from contractors

Available propulsion options for HD- and LD-trucks
- Battery
- Biodiesel
- Hydrogen

Challenges/Limitations
- Weight
- Range
- Cost
- Infrastructure
- Supply
- Engine reliability
- NOx-, PM-Emissions
- Cost
- Supply
- Stable fuel cells
- Cost

Hydrogen most promising technology for propulsion of HD- and LD-trucks in the future!
Coop is in the position to solve chicken and egg dilemma on its own

Who was or will be first?

Symbolic for fuel cell drive trains (heavy duty trucks)

- Coop car fleet
- Coop light duty trucks
- Coop heavy duty trucks

or

Symbolic for hydrogen refueling stations

- 241 Coop petrol stations
- Gas stations system and engineering skills
- Other locations
Similar TCO like with Diesel engines for fuel-cell truck operators in Switzerland

Exemption from LSVA Road Tax as “Incentive Rule” (Lenkungsabgabe)

TCO of Swiss truck operators

<table>
<thead>
<tr>
<th>Component</th>
<th>Diesel</th>
<th>Hydrogen</th>
</tr>
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<tbody>
<tr>
<td>Road tax*</td>
<td>17%</td>
<td>8%</td>
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<tr>
<td>Mainten.</td>
<td>11%</td>
<td>15%</td>
</tr>
<tr>
<td>Depr.</td>
<td>8%</td>
<td>3%</td>
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<tr>
<td>Overhead</td>
<td>43%</td>
<td>43%</td>
</tr>
<tr>
<td>Wages</td>
<td>18%</td>
<td>26%</td>
</tr>
</tbody>
</table>

100% = TCO<sub>t</sub> (today)  100% = +/- 100% of TCO<sub>t</sub>

Incentive rule for 'electric trucks' in Switzerland:

- LSVA road tax was introduced in 1990's to transfer goods transportation from road to rail
- Amounts to 6.9 – 8.3 Mio. ISK (50'000 - 60'000 EUR) per year for a 40 to truck (no matter if loaded or unloaded)
- Exemption from LSVA road tax for fc-truck is giving similar TCO's as for diesel trucks
- For fc-trucks in Switzerland there is a profitable business case given already today

* Including insurance and interests, exemption of LSVA
Why availability of hydrogen trucks and/or buses is so vital to successfully establish HRS networks

- 30-50x more hydrogen p.a.
- 5-7 t per truck and year
- HRS close to distribution centers
- Refueling cycles are given (where, when, how much)
- Planning much easier

- Optimized utilization of infrastructure
- Less expensive technology
- 35 MPa
- Educated professional drivers
- 130-170 kg per car and year
- Point-to-point routes need more HRS points
- Filling cycles with peaks
- 70 MPa
- Stable and easy to use technology
Coop 'hydrogen cycle' as a blueprint for a renewable fuel infrastructure

**Hydrogen vehicles** convert hydrogen into electricity and water vapor

**Run-of-the-river-plant** delivers renewable electricity

**Coop hydrogen refueling station** offers hydrogen to its customers

**Swiss Hydrogen Cycle**

**H2 Energy’s electrolyser** transforms water and renewable energy into hydrogen

**H2 Energy’s hydrogen trailer** stores and delivers hydrogen
Functioning H₂ Energy hydrogen production plant, Coop HRS and fuel cell truck

H₂ Energy electrolyzer and trailer refilling station

Coop HRS with H₂ Energy Trailer in the background

Coop fuel cell truck and cars
Coop 34t truck with trailer, refrigeration unit and range of 400 km

**Fuel cell system**
100kW

**H2 dispenser**
35 MPa high flow
Left to cabin

**Chassis**
MAN TGS

**H2 refilling system**
7x4.9 = 34.3 kgH2 gross
→ net load 31 kg H2

**Electric motor**
Synchronous motor
250KW continuous

**Electric plug-in**
Left side, 2x22kW
only on weekends

**Battery**
Total 120kWh (2x60 kWh),
left and right side

**Cooling system**
Underneath, electric supply of trailer cooling system

**Composition**
Load volume: 30 units
(normally 33)
Fuel cell trucks are proven and can replace diesel trucks for goods distribution

Operational experience

• Up to date about 30'000 km are accumulated
• Full replacement for a 34 to diesel truck for distribution of goods
• Concept and technology demonstrated the applicability in every-day use
• Emission-free and noise-less operation is significant advantage for inner-urban operation
• Energy management system is crucial

Truck driver's experience

• Strong acceleration
• Quiet driver's compartment
• Smooth vehicle handling, easy maneuvering
• Image booster for truck drivers

Source: tagesanzeiger.ch
The Swiss Hydrogen Association is coordinating built-up of HRS-network and members will operate fc-truck-fleet.

- Association founded May 17th, 2018
  - Jointly operating ~1’600 petrol stations (>50%) and ~2’000 heavy duty trucks in operation
  - Associated to major third party logistic partners
  - Dedicated to jointly establish nationwide refueling station network in Switzerland until 2023
- Restricted to renewable energy only (‘green’ hydrogen)
- Shell (Switzerland) AG and Emil Frey Group joined Oct. 8th, 2018
Rule of thumb for successful scaling up trucks/busses to HRS – 10:1

- Profitability achieved as soon as 10 trucks or busses regularly refuel at the station
- Basis: today’s cost structure; already after the second HRS substantial cost savings can be achieved
- Further potentials
  - Retail revenues convenience shop
  - Revenues by passenger cars
  - Buses
Basic supply of 95% of Swiss population with hydrogen for transportation can be reached with <50 HRS
Next hydrogen refilling station within 20 km range

Estimated positioning of HRS with a radius of 15 km

Upscaling of HRS-network
- Initial HRS-network for trucks, close to goods distribution centers
- 'Natural' expansion of HRS-network according to growth of fuel cell truck fleet
- Currently 3 additional HRS (Zürich, Basel, Bern) are in preparation in
- Trucks are 'the HRS-pathfinder' for cars
- Less than 50 HRS can provide access to hydrogen for >90% of the population within <20 km of distance
Summary

• Fossil trucks/busses in typical operation are having larger energy consumption and larger CO2-emissions than cars; fc-trucks/busses are providing significant larger potential for CO2-reduction

• FC-trucks for distribution of goods in Switzerland (structure and topography) are working properly and can replace diesel powered trucks

• Due to dedicated incentive rule in Switzerland, fc-trucks are having similar TCO as diesel trucks and a business case is given already today

• Commercial fc-trucks are having a given refueling cycle:
  - when
  - where
  - how much
  ⇒ reliable data for designing hydrogen supply chain and HRS-network

• FC-trucks will be 'the pathfinder' for the wide-spreaded introduction of fc-cars
Change can happen quickly

**Easter Monday, 1900:**
5th Avenue, New York City

*Do you see the automotive car?*

**Easter Monday, 1913:**
5th Avenue, New York City

*Can you spot a horse?*
Thank you for your attention!

info@h2energy.ch